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ABSTRACT

Adult students taking a dimensional metrology course usually do so to fulfill a need for their present employment, advancement, or expected employment. In order to assure that the quality of training is maintained it has become necessary to investigate alternatives to existing instructional approaches whereby the contents of the course can be within the existing number of classroom hours. The purpose of this research was to compare the time difference between use of metric and customary measurement instruments by adults trained in the use of both measuring systems. The methodology included measuring industrial parts by two measuring instruments commonly used in industry. Sample questions, standard deviations, and t-test calculations are appended. (KR)

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A COMPARISON OF TIME NEEDED TO COMPLETE MEASUREMENT TASKS USING CUSTOMARY AND METRIC SYSTEMS

ED 253334

APPLIED EDUCATIONAL RESEARCH AND EVALUATION

by

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DALLAS II

A PRACTICUM PRESENTED TO NOVA UNIVERSITY
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ABSTRACT

With the introduction of the metric system, education has been enthusiastic about the simplification of teaching and learning tasks. However, since the comprehensive "Report to Congress" by the United States Department of Commerce in 1971, education has not emphasized the teaching of the metric system at the adult level although metric units are often used in industry. As a result, da is not available to support claims of adult productivity advantages by the use of a measurement system based on units of ten.

The purpose of this research has been to obtain data from adult students who have been trained in the use of both customary and metric units, for linear measurements, and compare the time difference between use of metric and customary measurement instruments.

The methodology included actual industrial parts with measurements performed by two basic measuring instruments commonly used in industry. The comparison was based on data obtained from eighteen adult students performing the same measurements in two measurement systems, customary and metric. The dependent variable is the time required to complete the measurements for the two measurement systems.

Finding of this experimental research revealed that the average time difference was 17.7 percent less time required to perform measurements in the metric system. Further statistical analysis proved this time difference was significant, using a .05 level of significance for a dependent two-tailed t-test.

Based upon the results obtained, it is recommended that additional laboratory exercises be converted to the use of metric measuring instruments in order to provide additional classroom time.

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INTRODUCTION

Adult students taking a dimensional metrology course usually do so to fulfill a need for their present employment, advancement, or expected employment. Due to the severe consequences of improper training in a precision measurements course (product liability, scrap costs, etc.) such training must include the actual use of measurement instruments. While the contents of the course have continued to expand, the allowed classroom hours have remained constant.

In order to assure that the quality of training is maintained it became necessary to research alternatives to existing institutional techniques, whereby the expanded contents of the course can be achieved within the existing number of classroom hours. Thus, the consideration of merging measurement instructions to only one system of units of measure has been evaluated in this research as a means to increase education productivity.

To accomplish this investigation, an experimental project was designed whereby a class of adult students, knowledgeable of both customary and metric measuring instruments, were timed to determine if a significant difference existed between the two measurement systems. Each student made the same measurements

with both types of measuring instruments; thus, time was used as the dependent variable for evaluation by use of the two-tailed t-test.

STATEMENT OF THE PROBLEM

Adult students in a dimensional metrology course are trained to be proficient in measuring linear distance in both customary and metric units of measure. After such proficiency has been attained, laboratory assignments have continued to use both measurement systems, customary and metric, with students often unable to complete laboratory assignments within the scheduled time. Make-up labs are extremely difficult to schedule due to other classes using the classroom, amount of equipment required, and security of assets in the classroom. The reduction of lab assignments would lower the quality of instruction by eliminating the application of concepts covered in the lecture, reduce the reinforcement of instruction, and eliminate the use of some measuring instruments that adult students are expected to utilize in their employment.

The purpose of this research was not to justify the replacement of either measurement system, but to analyze the time difference of obtaining measureable data in only the metric system. Although adult students must be proficient in both measurement systems, the objective of this research was to determine if the metric system will provide a contribution to adult education by requiring less time for

gathering of data. In addition, this research data can further be utilized in the future to provide the basis for a hypothesis that the adult learning experience can be achieved in more detail and in less time by the elimination of distractions due to bilingual data and measurements.

RESEARCH HYPOTHESIS

Adult students can perform linear measurements in less time using metric instruments than customary instruments.

BACKGROUND AND SIGNIFICANCE OF THE STUDY

The United States policy regarding the use of metric units of measure is that of voluntary conversion as provided for in the Metric Conversion Act of 1975, Public Law 94-168, dated December 23, 1975. Today, the metric system is slowly advancing in adult education although sporadically and in an unorganized manner. The predominate use of the metric system is generally centered about science courses, such as physics and chemistry, where traditionally metrics has been the predominate measurement language. However, reference to textbooks using the metric system readily revealed that data is provided or obtained in mixed units of measure, thus requiring additional instructions and unnecessary steps to convert to a given measurement language.

The motivation for this research, which is concerned only with the time element of linear measurements, is provided by the often stated advantages of the metric system; but the lack of supporting data. The lack of data was re-confirmed during the Annual Conference of the United States Metric Association held in San Francisco, California, 7 - 8 October, 1983. Conference speakers noted the advantages of metric measurements but could not support such statements with applied research and data evaluation.

DEFINITION OF TERMS

Following are terms which may be unfamiliar and therefore require further clarification. The expressions are pertinent to the discussion of the research.

Adult Student - those students employed full time and attending evening classes. For purposes of this research adult student is further defined as those students who attended the fall, 1983 evening class for QCT 122, Dimensional Metrology, Richland College, Dallas, Texas.

Customary Units of Measure - the predominant measurement system in use which consists of units such as inches, pounds, gallons, etc.

Measuring Instruments - (1) 0 - 1 inch vernier outside micrometer with a discrimination of .0001 inch and;

(2) 0 - 6 inch vernier caliper with a discrimination of .001 inch, and;

(3) 0 - 25 millimeter vernier outside micrometer with a discrimination of .002 millimeter, and;

(4) 0 - 150 millimeter vernier caliper with a discrimination of .05 millimeter.

Metric System - the international system of units as established by the General Conference of Weight and Measures in 1970, and identified as SI (for Systeme International d'Unites).

LIMITATION OF STUDY

Limitations are:

1. This research was based on data obtained from the QCT 122 Dimensional Metrology class conducted at Richland College.
2. Data for the research was obtained during December, 1983. This limitation is noted to emphasize the use of students who met the definition of "adult student," had received training, and demonstrated their proficiency in the performance of both customary and metric units of measure.

3. Instrument adjustment time from one reading to the next was not a factor. Parts selected for this experiment were uniform in size to keep the range of adjustments equal for each student.

BASIC ASSUMPTIONS

Based on prior performance and testing, all students within the selected population had equal training and proficiency in performing linear measurements utilizing both customary and metric instruments. Items to be measured were of reasonable uniformity in regards to actual size.

PROCEDURES FOR COLLECTING DATA

Each of the eighteen students in the class (population) was provided a sketch and data sheet of the parts to be measured. The sketch indicated the features to be measured and instruments to be used and also contain the serial number of the part used. The use of serial numbered parts provided the researcher with traceability of each measurement taken.

One-half of the class recorded units of measure and the other half timed. The timing began after the instructions had been acknowledged as having been clearly understood and with the student holding the part and first measuring instrument. After timing had started, the time for each measurement was recorded as the student

measured each dimension. Upon completion, the two groups alternated. All students participated equally with time for the two measurement systems being the dependent variables.

See Appendix A and Appendix B for data sheets.

PROCEDURES FOR TREATING THE DATA

The raw data were collected and converted from minutes and seconds to minutes in decimal form for ease of calculation. The bivariate objective of this study was the comparison of measurement time totals for customary and metric. The independent variable was the measurement exercise performed by adult students in two units of measures; with the dependent variables being the time required for the two systems of measurement. The selection of these variables was based upon the same population performing two tasks in contrast to the use of two separate groups for each task. Thus, the element of separate physical tasks by the same population was the basis for this statistical analysis. The null hypothesis was tested at the .05 level of significance, utilizing the dependent, two-tailed t-test.

The null hypothesis is designated as H_o, the corresponding research hypothesis is designated as H_{a_1}, and the alternate hypothesis as H_{a_2}; where $\overline{X}_E$ = time for metric measurements and $\overline{X}_o$ = time for customary measurements.

The null hypothesis is as follows:

H_o: There is no significant difference in the time required to perform measurements in the metric system than in the customary system ($\overline{X}_E - \overline{X}_o = 0$).

The corresponding research hypothesis is as follows:

H_{a1}: There is significantly less time required to perform measurements in the metric system than in the customary system ($\overline{X}_E < \overline{X}_o$).

The corresponding alternate hypothesis is as follows:

H_{a2}: There is significantly more time required to perform measurements in the metric system than in the customary system ($\overline{X}_E > \overline{X}_o$).

Depending upon the results, the null hypothesis was rejected or accepted based upon a .05 level of significance, utilizing the dependent, two-tailed t-test.

DATA RESULTING FROM THE STUDY

The data obtained is provided below for purposes of future reference and comparison of replicated studies. Analysis of the data reveals a mean time of 7.76 minutes and 6.39 minutes for customary and metric measurements respectively, resulting in a 17.7 percent difference. In addition, the customary standard deviation is 1.896 with a range from 4.23 to 10.83 minutes and the metric standard

deviation is 1.557 with a range from 3.70 to 8.62 minutes. See Appendix C for calculations.

DATA OBTAINED FROM EXPERIMENT

	Time (Minutes)					
	Customary			Metric		
Student	Micrometer	Vernier Caliper	Total	Micrometer	Vernier Caliper	Total
1	3.23	2.75	5.98	2.33	1.83	4.16
2	5.70	4.95	10.65	4.02	2.92	6.94
3	3.00	1.72	4.72	3.83	1.52	5.35
4	4.42	1.75	6.17	3.42	1.58	5.00
5	5.82	2.17	7.99	5.17	3.37	8.54
6	3.75	3.08	6.83	3.08	1.77	4.85
7	2.15	2.08	4.23	1.85	1.85	3.70
8	4.00	3.90	7.90	3.92	3.25	7.17
9	4.62	2.55	7.17	3.12	1.47	4.59
10	4.83	2.67	7.50	4.25	2.25	6.50
11	4.23	4.47	8.70	4.38	3.83	8.21
12	5.58	2.35	7.93	5.42	2.07	7.49
13	3.80	3.15	6.95	3.42	2.08	5.50
14	4.62	5.47	10.09	3.58	3.75	7.33
15	5.17	5.08	10.25	4.50	3.67	8.17
16	3.67	2.67	6.34	3.17	2.08	5.25
17	5.25	5.58	10.83	5.08	2.58	7.66
18	5.15	4.33	9.48	3.95	4.67	8.62
TOTAL	78.99	60.72	139.71	68.49	46.54	115.03
$\overline{X}_T$	4.39	3.37	7.76	3.80	2.59	6.39

The null hypothesis was evaluated at the .05 level of significance, utilizing the dependent two-tailed t-test. With $t_{.05} = 2.110$ the calculated t value was 4.695. See Appendix D for calculations.

CONCLUSIONS AND SIGNIFICANCE

Since the calculated value of t (4.695) exceeds the critical t value (2.110), the null hypothesis is rejected. There is a significant difference between the time required to perform measurements in customary and metric units of measure. Thus, the research hypothesis (H_{a_1}) is accepted which reveals that significantly less time was required to perform the measurements in the metric system.

The purpose of this research set forth the objective of determining if additional classroom time could be provided by merging measurement instructions to one system of measurements. With the resulting parametric data determining the probability that the difference between the means is a real difference, rather than a chance difference, it is recommended that the current laboratory manual Metron Logos be supplemented to convert selected customary measurements to metric measurements. A follow-up review is further recommended for January, 1985 to determine if previous scheduling problems, as noted in the introduction section of this report, have been reduced.

RESIDUAL FINDING

At the conclusion of the experiment, each student was offered a chance to comment on any aspect of the design and conduct of the

experiment. The most significant and predominant comment received concerned the design of the metric micrometer used. The marking on the barrel of the instrument was felt to be too wide resulting in additional time to assure the accuracy of the reading. Evaluation of other brands reveal this observation to be valid. This information has been passed on to the local distributor and will be used in the selection of new instruments for the college.

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APPENDIX A

Name _____

Date _____

QCT 122

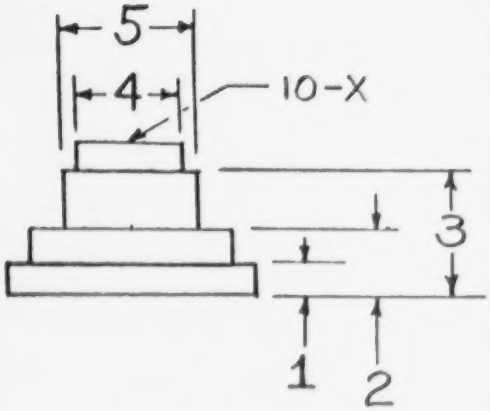
CUSTOMARY UNITS OF MEASURE

Equipment required: Part No. 7, Dash No. _____
Part No. 10, Dash No. _____

0 - 1 inch outside vernier micrometer x .0001 inch
0 - 6 inch vernier calipers x .001 inch

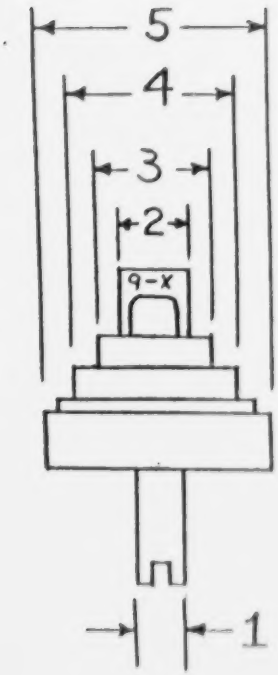
Instructions: Perform and record measurements to the nearest unit of discrimination for the indicated measuring instrument. This is a timed exercise which begins with you holding the part and instrument at the ready position to perform the first measurement - not in contact with each other and the word "start" given by the instructor. Your partner will note the cumulative time for each measurement upon the completion of your recording the measurement. Do not stop until all micrometer measurements are completed, at which time we will again start timing at the ready position for the vernier caliper measurements. All timing will be taken from the large clock at the front of the room and will be transferred by your partner to this sheet upon completion of the exercise.

Concentrate on accuracy rather than time.



MICROMETER

Student	Partner	
	Start Time	0:00
Measurement	Unit Time	Cum Time
1. _____ inches	:	:
2. _____ inches	:	:
3. _____ inches	:	:
4. _____ inches	:	:
5. _____ inches	:	:



VERNIER CALIPERS

Student	Partner	
	Start Time	0.00
Measurement	Unit Time	Cum Time
1. _____ inches	:	:
2. _____ inches	:	:
3. _____ inches	:	:
4. _____ inches	:	:
5. _____ inches	:	:

APPENDIX B

Name _____

Date _____

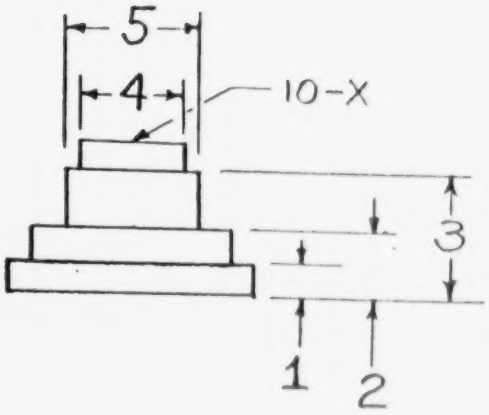
QCT 122

METRIC UNITS OF MEASURE

Equipment Required: Part No. 7, Dash No. _____
Part No. 10, Dash No. _____
0 - 25 millimeter outside vernier micrometer x .002 millimeter
0 - 150 millimeter vernier calipers x .05 millimeter

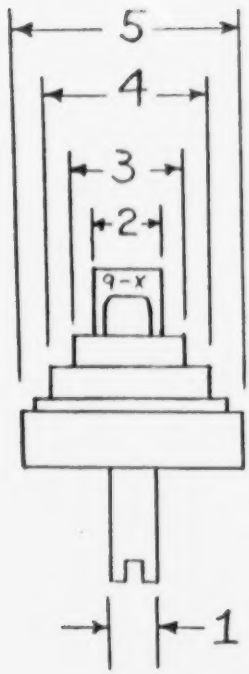
Instructions: Perform and record measurements to the nearest unit of discrimination for the indicated measuring instrument. This is a timed exercise which begins with you holding part and instrument at the ready position to perform the first measurement--not in contact with each other and the word "start" given by the instructor. Your partner will note the cumulative time for each measurement upon the completion of your recording the measurement. Do not stop until all micrometer measurements are completed, at which time we will again start timing at the ready position for the vernier caliper measurements. All timing will be taken from the large clock at the front of the room and will be transferred by your partner to this sheet upon completion of the exercise.

Concentrate on accuracy rather than time.



MICROMETER

Student	Partner	
Measurement	Start Time Unit Time	0:00 Cum Time
1. _____ mm	:	:
2. _____ mm	:	:
3. _____ mm	:	:
4. _____ mm	:	:
5. _____ mm	:	:



VERNIER CALIPERS

Student	Partner	
Measurement	Start Time Unit Time	0:00 Cum Time
1. _____ mm	:	:
2. _____ mm	:	:
3. _____ mm	:	:
4. _____ mm	:	:
5. _____ mm	:	:

APPENDIX C

STANDARD DEVIATION CALCULATIONS

	Customary		Metric	
Student	Time (x)	x^2	Time (x)	x^2
1	5.98	35.76	4.16	17.31
2	10.65	113.42	6.94	48.16
3	4.72	22.28	5.35	28.62
4	6.17	38.07	5.00	25.00
5	7.99	63.84	8.54	72.93
6	6.83	46.65	4.85	23.52
7	4.23	17.89	3.70	13.69
8	7.90	62.41	7.17	51.41
9	7.17	51.41	4.59	21.07
10	7.50	56.25	6.50	42.25
11	8.70	75.69	8.21	67.40
12	7.93	62.88	7.49	56.10
13	6.95	48.30	5.50	30.25
14	10.09	101.81	7.33	53.73
15	10.25	105.06	8.17	66.75
16	6.34	40.20	5.25	27.56
17	10.83	117.29	7.66	58.68
18	9.48	89.87	8.62	74.30
Σx	139.71		115.03	
Σx^2		1,149.08		778.73

$$s = \sqrt{\frac{n(\Sigma x^2) - (\Sigma x)^2}{n^2}}$$

Customary

$$s_C = \sqrt{\frac{18(1,149.08) - (139.71)^2}{18^2}}$$

$$s_C = \sqrt{\frac{20,683.44 - 19,518.88}{324}}$$

$$s_c = \sqrt{\frac{1164.56}{324}}$$

$$s_c = \sqrt{3.594}$$

$$s_c = 1.896$$

Metric

$$s_m = \sqrt{\frac{18(778.73) - (115.03)^2}{18^2}}$$

$$s_m = \sqrt{\frac{14,017.14 - 13,231.9}{324}}$$

$$s_m = \sqrt{\frac{785.24}{324}}$$

$$s_m = \sqrt{2.424}$$

$$s_m = 1.557$$

APPENDIX D

DEPENDENT TWO-TAIL t-TEST CALCULATIONS

Student	T_c	T_m	D	D^2
1	5.98	4.16	1.82	3.312
2	10.65	6.94	3.71	13.764
3	4.72	5.35	-.63	.397
4	6.17	5.00	1.17	1.369
5	7.99	8.54	-.55	.302
6	6.83	4.85	1.98	3.920
7	4.23	3.70	.53	.281
8	7.90	7.17	.73	.533
9	7.17	4.59	2.58	6.656
10	7.50	6.50	1.00	1.000
11	8.70	8.21	.49	.240
12	7.93	7.49	.44	.194
13	6.95	5.50	1.45	2.102
14	10.09	7.33	2.76	7.618
15	10.25	8.17	2.08	4.326
16	6.34	5.25	1.09	1.188
17	10.83	7.66	3.17	10.049
18	9.48	8.62	.86	.740
TOTALS	139.71	115.03	24.68	59.991

$$\overline{D} = \frac{\Sigma D}{n} = \frac{24.68}{18} = 1.371$$

$$\Sigma D^2 = 59.991$$

$$n = 18$$

$$\Sigma d^2 = \Sigma D^2 - \frac{(\Sigma D)^2}{n}$$

$$\Sigma d^2 = 59.991 - \frac{24.68^2}{18} = 59.991 - \frac{609.102}{18}$$

$\Sigma d^2 = 59.991 - 33.839$

$\Sigma d^2 = 26.152$

$df = n - 1 = 18 - 1 = 17$

$\alpha = .05$, dependent two-tailed t-test

$t_{.05} = 2.110$

$$t = \frac{\bar{D}}{\sqrt{\frac{\Sigma d^2}{n(n-1)}}} = \frac{1.371}{\sqrt{\frac{26.152}{(18)(17)}}}$$

$$t = \frac{1.371}{\sqrt{\frac{26.152}{306}}} = \frac{1.371}{\sqrt{.0855}} = \frac{1.371}{.292}$$

$t = 4.695$

$4.695 > 2.110$

END

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